Appendix K: Whole Air Sampling System

K.1 Operational Description

Keeping track of the large number of samples involved in a typical tracer field program is a difficult process requiring careful record keeping. The samples must be tracked through the analysis process and the results associated with the correct time and place. The logistics of this process are complex and errors can easily occur. We have developed an integrated Whole Air Sampling System that uses barcodes, computer data storage, and a relational database to keep track of samples, sample cartridges, analytical results, and cartridge history. The steps required to operate the equipment collect data on sample time and location and automatically associate this with the analysis results. All of the data is transferred electronically.

The following eight steps explain the operation of the system. They have been kept simple with the intent of providing an overview. The various components are explained in more detail below.

1. The process begins with the location of the sampling sites. A location number is assigned to the site. A bar code tag with the number on is left at the site, typically attached to a post. The latitude and longitude is measured by differential GPS and recorded on a laptop computer. The operator enters the location number for each site into the computer as the samplers are placed. The location information is uploaded to the system computers. It becomes part of the "history files". These files are an electronic log of all operations performed on the samplers or sampler bags.

2. Before sampling begins, an operator programs sampling information into a TimeWand II. This is a handheld computer with a built-in bar code reader manufactured by Videx, Inc. The TimeWand II's are used to operate the samplers. The sampling information includes start time, sampling time for each bag, and a test and project ID.

3. A TimeWand II is taken to each sampler site. The operator installs a cartridge in the sampler. The TimeWand II is connected to the sampler with a RS232 cable and the operator scans the bar code labels on the sampler, cartridge, and location tag. The TimeWand II then downloads the sampling information into the sampler.

4. After the sampling is complete, the cartridges are removed from the samplers. The TimeWand II's are used to record the cartridge serial number and the pickup time.

5. When the cartridges are brought back into the analysis laboratory, the data from the TimeWand II's are uploaded into the history files.

6. The sample cartridges are then analyzed on a gas chromatograph (GC). A cartridge is connected to the GC and the serial number scanned into the computer operating the GC. The

computer then queries the history files and retrieves the location information (including the latitude and longitude), the sampling time and duration, and the test and project identifications. It then analyzes the samples and stores the results along with the position and sampling information in a raw data file.

7. Once the cartridges are analyzed, the data are extracted from the raw data file on each GC and stored in a relational database. Information about samples that were not analyzed is extracted from the history files directly.

8. The relational database is then used to generate data reports and statistics. It can also generate performance reports on the GCs, individual samplers, or operators.

Once the data is stored in the relational database, it can be manipulated, sorted, and analyzed in many different ways. All the information is in one place and can be readily accessed. Since it has all arrived electronically, the chances for human error are very low.

The operators keep hand written logs during every step of the process. In the event of an equipment failure or operator error, these are used to hand enter the data into the system. The relational database can usually be used to identify these problems by searching for missing or inconsistent data points.

K.2 Component Descriptions

K.2.1 Sampler and Cartridges

The samplers are a waxed cardboard box containing a single circuit board with a Motorola 68HC811A2 microcontroller, a power supply, and 12 miniature air pumps. A single D size battery powers the sampler. The circuit board is mounted in a waxed corrugated cardboard box, which provides an inexpensive weatherproof housing. Rubber tubing serves as inlet hoses for the pumps and allows easy connection of the sample bags.

The cartridge is a slightly smaller cardboard box designed to slip inside the sampler box. An aluminum frame across the top holds the 12 Tedlar bags attached to rubber tubes. Plastic clips on the tubes seal the bags when they are not connected to the sampler. The cartridge allows easy transport and handling of the sample bags and protects them from damage. The entire system is lightweight, relatively inexpensive, and has been used successfully in a wide range of weather conditions.

K.2.2 TimeWand II

The TimeWand II accomplishes two functions simultaneously. First, it downloads the operating parameters into the microcontroller on the sampler. It also collects data on the operation of the samplers in the field. It is a hand held computer with a built-in bar code wand and an RS232

port. To download the sampler, the RS232 port is connected to the sampler with a cable. The operator then uses the bar code wand to scan the sampler serial number, the cartridge serial number, and the location number. Once the TimeWand II has these three numbers, it sends the operating parameters to the sampler. It also stores the numbers, the time, and the sampling parameters in memory to be uploaded to the history files later. When the cartridge is analyzed on a GC, its serial number is matched with a location, sampler, and sampling time using this information collected by the TimeWand II.

Videx, Inc manufactures the TimeWand II. It has 128K bytes of memory and is powered by rechargeable batteries. It is designed for field use and has proven to be rugged and reliable. Hard drops onto concrete and steel have caused the only failures.

Connecting them to the RS232 port of a computer and running the setup software programs the TimeWand II. The sampling parameters are entered from the keyboard and then transmitted to the TimeWand II. Usually, several TimeWand II's are programmed and each one is used for part of the samplers in the test. This reduces the time needed for sampler servicing by allowing several operators to work simultaneously.

The TimeWand II has the ability to hold up to four sets of sampling parameters. The location number determines the set that is downloaded to the sampler. Numbers between 0 and 999 receive the first set; 1000 to 1999 receive the second set; 2000 to 2999 the third set; and 3000 or over receive the fourth set. By numbering the locations correctly, the project may be designed so that an operator with a single TimeWand II can service samplers with several sampling times.

K.2.3 Gas Chromatograhs

The gas chromatographs were designed and built by FRD for use with this system. Typically they are configured for measuring SF6, but may be configured to measure other gases. For SF6, they use packed columns and an ECD detector. What sets these GC's apart is the sample handling system that allows them to automatically analyze all 12 bags in a cartridge.

The GC and sample handling system are completely computer controlled. The cartridge is connected to the GC and its serial number is scanned into the computer with a bar code reader. The computer then retrieves the sampling and location information from the history files. Once it has this, it uses a multiport rotary valve to sequentially pull air from each sample bag and inject it into the GC. The output from the detector is digitized with a 20-bit analog-to-digital converter and automatically integrated and converted to concentration.

Once the GC has analyzed the cartridge, it records that the bag has been analyzed in the history files and stores the data in a binary raw data file. All the information collected by the TimeWand II's about the cartridge is stored with the data, eliminating the need to match data values with locations and times.

K.2.4 Relational Database

The purpose of developing a database was to improve the collection and facilitate the use of the data acquired from the whole air samplers. The Access relational database from Microsoft was chosen as the storage format. This database supports Structured Query Language (SQL), has a built-in report generator, macro language, forms support, and various administrative tools. The database, or any queried portion, can be saved in a variety of other database or text formats such as comma delimited or fixed length. This database format is also easily manipulated though the Visual Basic programming language, also from Microsoft, which speeds the development of Windows based applications.

Using a Visual Basic developed application; data is captured from binary files that are generated through the automated analysis routines that run the gas chromatographs. The capture program has built-in viewing of control charts and statistics for each GC, generating virtually real-time feedback on the status of the instruments

Using SQL any number of ad-hoc reports can be generated quickly to satisfy the needs of the principals of the test. The fields that are stored in the Access database are as follows:

RecordIndex	Internal use field for assuring uniqueness of records
FileName	The binary file from which the data originates
Record Number	The record number within the binary file implied by sequence
Date	The date the sample was run on the GC
Time	The time of day that the sample was run on the GC
GC	The GC number on which the sample was run
CartridgeSerial	The cartridge number of the sample
SamplerSerial	The sampler number that was used to fill the sample cartridge
LocationSerial	The location number (fixed location) where the sample was taken
Latitude	The latitude associated with the location number
Longitude	The longitude associated with the location number
SampleType	Type of sample (0=Sample, 1=Spike, 2=Blank, 3=Replicate,4=Cal)
ProjectID	Identifier for this test (i.e., OLAD)
TestNumber	The number of the test
StartDate	The day when the pump started taking this sample
StartTime	The time when the pump started taking this sample
Seconds	The number of seconds the pump ran while taking this sample
Bag	The number of the bag that constitutes this sample
GCPressure	The pressure registered by the GC while analyzing this sample
GCTemperature	The oven temperature registered while running this sample
GCRetentionTime	The retention time the sample was on the GC column
PeakArea	The area under the curve of the chromatogram
PeakHeight	The maximum height of the curve of the chromatogram
PeakCorrectedArea	The area corrected to Standard Temperature and Pressure (STP)

Concentration	The concentration of the sample in pptv
BadAnalysis	Flag set to determine the status of this sample (1=flat, 2=clipped, 4=suspect, 5=clipped but used anyway, 6= sample failure, 7=clips closed, 8=battery pulled, 9=exclude analysis)
CheckStatus	Flag for use with the check-in function
AnalysisCount	Keeps track of how many times a sample was analyzed
Attenuation	The attenuation of the ECD at the time the sample was analyzed